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DEVELOPMENT OF PLASTIC PACKING CONTAINERS FOR 115 MM ROCKET LAUNCHER AMMUNITION

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DOVER, NEW JERSEY

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Technical Memorandum 1079

DEVELOPMENT OF PLASTIC PACKING CONTAINERS FOR 115 MM ROCKET LAUNCHER AMMUNITION

by

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June 1963

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OBJECT

To develop a lightweight plastic container for the 115 mm XM54 booster rocket which would provide a water seal and physical protection to the round during shipment and storage and would be in the same general price range per round as the standard packing system. The standard system consists of 2 rounds individually packed in cylindrical fiber containers subsequently overpacked with a wooden box.

SUMMARY

A high-density polyethylene was chosen for fabrication of the XM54 rocket container because of its light weight, good water and impact resistance, and low cost. Several methods of fabrication were considered for this application, including blow molding, injection molding, and extrusion.

The concept of blow molding was eliminated because the close tolerances required in the inside diameter and the threaded section of the container could not be adhered to. Containers were fabricated utilizing extruded tubes and injection molded end caps, base and nose supports, and threaded closures. These containers were designed in two sections which were screwed together to form a sealed container. Difficulty was experienced with the heat-welded joints upon testing, and buckling of the container also occurred.

In view of this problem, it was decided to use a three-piece injection-molded container. Several minor design changes were made on the three-piece container on the basis of test results, thereby giving the final design shown in Figure 8 (p 27).

Of the several resins tested, the two that appear most promising are Alathon 2904 and Grace 60–015. Phillips 6015 may also be satisfactory if a proper mold design can be established for use with this resin. Further testing of resins and designs is required, and optimum molding conditions must be established before a completely satisfactory container can be produced.

CONCLUSIONS

This is an interim report evaluating only the basic resin and design. From results obtained, it appears feasible that a suitable packing container for the XM54 can be fabricated by correlation of the proper design (probably Design 3, shown in Figs 3 and 8, pp 22 and 27), the right molding conditions, and a suitable resin. Alathon 2904 resin and Grace 60–015 resin appear promising for this application, provided proper molding conditions are established. Phillips 6015 may also be satisfactory if a proper molding procedure can be established.

RECOMMENDATIONS

It is recommended that (a) optimum molding conditions be established for fabrication of future containers, (b) promising resins be further evaluated with Design 3, and (c) on the basis of results of tests of Design 3, further design modifications be made, if necessary.

INTRODUCTION

The Plastics and Packaging Laboratory was requested by ARGMA to design and develop a lightweight packing container for the XM54 booster rocket. The design studies were prepared in two phases:

a. An "Interim Design Phase" consisting of 2 individual cylindrical fiber containers overpacked in a wooden box (see Fig 1, p 20). This design was prepared to meet a deadline test date to provide for immediate use.

b. An "Improved or Ultimate Design Phase" consisting of a plastic container, the development of which will extend over a longer period. The plastic container should have the following advantages over the old fiber container-wood box pack: increased water and water vapor protection, reduced weight and volume, and greater ease in packing and unpacking.

Four designs, two for Phase 1 and two for Phase 2, were submitted to ARGMA. The Interim Design Phase 1 was accepted and the required number of containers were supplied.

Considerable interest was shown in the plastic container as a possible replacement for the conventional fiber container-wood box pack and the Plastics and Packaging Laboratory at Picatinny was asked to proceed with its investigation of the plastic container.

RESULTS

Containers fabricated from several resins with 3 basic design changes were drop tested. Physical properties were determined on specimens cut from containers. Melt indexes were determine d according to ASTM D 1238–57T, densities by the density-gradient technique of ASTM D 1505–60T. Tensile tests were conducted on the Baldwin PTE–21 test machine by ASTM method D638–61T. A crosshead speed of 2 inches per minute was used for tests conducted at 160°F and 73°F while 0.2 inch per minute was used for the tests conducted at –65°F.

Tests were also conducted on ring specimens cut from containers in order to compare the tensile strength longitudinally and circumferentially, thereby determining whether molecular orientation was affecting the container properties. This ring test is described in NAVORD report 5680, "Proposed NOL Ring Test Method," July 1957.

Manufacturers data is also presented. Results are given in Tables 1 through 9 (pp 11 through 19). Molding conditions, where known, are also reported here.

DISCUSSION

The decision to use a thermoplastic container in the place of the initial fiber container-wood box pack for the 115 mm rocket ammunition was arrived at by considering the physical and chemical properties of various plastics and their ability to withstand the rugged treatment that military packages must undergo and still protect their contents from moisture during outdoor storage. The use of a plastic container would eliminate the need for the outer box, thereby providing a lightweight small-volume package which is desirable in current military logistics.

Representatives of industry were contacted and various plastics, methods of fabrication, and designs were discussed. Among the plastic materials considered were filled and unfilled polyethylene (regular and linear) and filled and unfilled polypropylene. The methods of fabrications considered were blow molding, injection molding, and extrusion.

Linear (high density) polyethylene appeared to be the most desirable material since it possessed the necessary combination of properties, namely light weight, good impact strength, negligible water absorption (0.1% in 24 hours), a cost falling within the desired price range, and relatively high mechanical properties at -65°F and +160°F.

Several methods of fabrication were considered. The first was blow molding, which was recommended by several sources as the most practical procedure to provide optimum mechanical properties, low tooling costs, and ease of molding. However, this method had to be discarded since the critical container dimensions could not be adhered to.

The second method considered was to fabricate the containers by using extruded container tubes and injection molding such other parts as end caps, base and nose supports, and threaded closures. These parts would then be assembled into two main sections by heat welding. The two sections would then be screwed together to form a sealed container. (See Figs 2 and 3, pp 21 and 22).

Manufacture of prototype containers by this inexpensive method, in addition to producing a "feel" for the container, resulted in two important

findings: (a) that a plastic container based on this concept (one container section for the cartridge case and one section for the projectile, threaded together) is feasible, and (b) that the weak point in this design is the heat-sealed joints. The containers were separating at the heat-welded joints during testing. Buckling of the aft end (charge case) was also occurring. This failure of the heat-welded joints could be attributed partly to the fact that the extruded tubing tended to lose its circular shape on standing, thereby making it difficult to obtain a good heat seal to an end adaption that was circular. Buckling also occurred in the short (aft end) of the container which held the charge. The buckling could be eliminated by reinforcing the part with ribs. However, it was felt that if heat welding presented a problem on these few sample containers under controlled laboratory fabricating conditions, it would be even more serious in mass production.

Since the aft end was short it could be injection molded, thereby eliminating heat sealing problems in this area. This led to the idea of a 3-piece container. A forward end section identical to the aft end could be used and both could be made in the same mold. A middle extension would then be necessary to make up the required length of the container. The design for the 3-piece injection-molded container (Design 1) is shown in Figures 4 and 5 (pp 23 and 24).

Bids were sent out for the molding of this container and Molded Insulation Corporation, which made the lowest bid and had satisfactory facilities, was selected.

In selecting a resin for the container, it was decided to try to obtain a melt index of about 1.5 and a density of 0.96. This combination of melt index and density would theoretically provide a strong, rigid material with good resistance to stress cracking. The first 3-piece plastic containers were injection molded using Phillips 6015 polyethylene resin, since it met the density and melt index requirements, and DuPont's Alathon 2886 resin, which had a 0.96 density and a melt index of 3.0. Although the Alathon 2886 had a higher melt index, it was reported to have a very narrow molecular weight distribution which would produce a tough part with a minimum of internal stress. The higher melt index would also reduce mold filling problems. Pilot lots of 5 containers of each resin were specified to be manufactured by Molded Insulation Corporation and submitted to Picatinny Arsenal for testing. However, difficulty was experienced in molding the midsection of the container.

The trouble was found to be mainly in the mold design. Initially, the molding material was fed from a small sprue to a ring runner and in turn this runner fed four gates equally spaced around the circumference at one end of the container. The gate nearest the sprue was being fed hotter material than the gates farther away from the sprue, as a result of which shrinkage was uneven. Thus the molded threads on the midsection were very wavy and impossible to engage. The situation was slightly improved by shutting off the gate nearest the sprue. By making a complete ring gate and keeping the ring thinnest near the sprue and thickest away from the sprue, molding was greatly improved.

With the close cooperation of DuPont personnel, good containers were obtained with the Alathon 2886 material. Difficulty was still experienced, however, in producing satisfactory containers of the Phillips 6015 resin.

The first molded containers received at Picatinny were molded of Phillips 6015 and Alathon 2886. These containers had a buttress thread design (Shown in Fig 4, Design 1, p 23).

When these containers were subjected to drop testing, it was found that the threads slipped very easily at room temperature and the midsections of the containers cracked. This thread slippage was due to distortion of the threaded sections of the container upon dropping.

In view of these results, the following additional design changes (See Fig 7, Design 2, p 26) were made:

1. The buttress thread was replaced by a square thread 0.1 inch deep.

2. The number of threads per inch was decreased from 8 to 6.

3. The thickness of the midsection was increased from .17 inch to .20 inch.

Containers of Alathon 2886 were fabricated using this design (See Fig 7).

The Phillips 6015 resin was dropped from investigation at this time because of the aforementioned molding problems which had not yet been resolved.

Three plastics manufacturers, W. R. Grace Plastics Company, Union Carbide and Carbon Corporation, and Dow Chemical Corporation, submitted

free sample containers for testing. It is understood that private arrangements were made with these companies and Molded Insulation Corporation to fabricate these containers. Plastics and Packaging personnel gave the contractor permission to use their mold for this operation. The containers submitted were fabricated in accordance with Design 2 and molded of the following resins: Dow 401 and 600, Union Carbide DMDA 7125 and 6087, and Grace 60–015. DuPont also submitted another resin, Alathon 7511.

All of the containers were tested. The Alathon 2886 containers were drop tested at temperatures from –65°F to 160°F. They were also subjected to storage at 160°F for 48-hour and 100-hour periods to determine the effects of thermal stress. Thread slippage was observed on all drop tests. Containers cracked upon dropping at –65°F. They passed storage for 48 hours at 160°F but cracked when stored for 100 hours at this temperature.* They also cracked when immersed in boiling water for 4 hours (See Tables 1 and 2, pp 11 and 12).

Only a few of each of the other containers were available. Therefore, they were not tested over the complete temperature range. The Alathon 7511 was drop tested at –40°F only, at which temperature it cracked in the aft end. The aft end also stress cracked at the base of the ribs after 72 hours storage at 160°F (Table 4, p 14). The Dow 401 and Dow 600 containers were each drop tested at –40°F and 73°F. Both containers cracked at –40°F and exhibited thread slippage at 73°F. When these containers were stored for 72 hours at 160°F, the aft ends of both stress cracked at the base of the ribs (Tables 7 and 8, pp 17 and 18).

Only two Grace 60–015 containers were received. One was drop tested at –40°F and the other was subjected to 72 hours storage at 160°F. Both containers passed without cracking or thread slippage (Table 9, p 19).

Only two each of the Bakelite 6087 and 7125 containers were received. One of each of these was also drop tested at –40°F and one each was stored for 48 hours at 160°F. They cracked at –40°F, but passed the storage test without noticeable effects.

In view of the thread slippage which was still occurring at room and elevated temperatures, a change in thread design was made. The depth of the thread was increased from .1 inch to .15 inch and the number of threads per inch was decreased from 6 to 4. The OD of the end sections was increased from 5.760 to 5.860 (Design 3, Fig 8, p 27). In molding these new

*It should be noted that the Alathon 2886 containers that were stored for 48 hours and 100 hours had the same design but were taken from two different batches of containers.

containers, the contractor made the desired changes except for the decrease in the number of threads per inch. Although they increased the depth of thread as specified, they maintained the old 6-thread-per-inch requirement.

Testing the Alathon 2886 resin was discontinued and Alathon 2904 resin was used instead for the new containers. Alathon 2904 consisted of 2886 resin with stabilizer, antioxidant, and coloring agent added. These containers were drop tested over a temperature range of from -65°F to 160°F and stored for 24 hours at 160°F. The containers cracked when dropped at -65°F. At -40°F one container passed all drop tests and another failed on the first drop. They passed room temperature and 160°F drop tests without cracking or slipping. No stress cracking was observed after storage for 24 hours at 160°F. The failure at -40°F is attributable to embrittlement of the material. When the tested containers were cut for tensile and ring specimens, large crystals of a foreign matter were found throughout the material (See Fig 9, p 28). Breaks usually occurred in these areas. Holes due to improper molding conditions were also found in the thick sections at the base of the ribs (Fig 9 and Table 3, p 13). In view of these results, it is considered necessary to fabricate more containers utilizing the most promising resins with Design 3. Close control of molding conditions must be established and the new containers shall be drop tested over a temperature range of -65°F to 160°F and subjected to storage tests over the same temperature range. Results of these tests will be given in a later report.

EXPERIMENTAL PROCEDURE

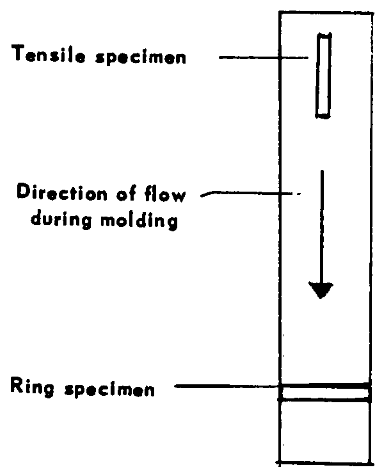
In addition to drop tests, tensile and tensile ring tests were conducted on all materials.

One container from each batch received was cut into test specimens. Tensile specimens were cut parallel to the direction of flow of the material (as shown on page 9) and tested in tension in the same direction as per ASTM Test Method D638–61T. Ring specimens were cut at a 90° angle to the direction of flow and tested in tension in this direction. Ring tests were conducted in accordance with the NOL ring test described in NAVORD report 6153.

These tests were conducted to determine the degree of "anistropy" or nonuniformity of properties within the molded containers caused by the tendency of molecules to orient themselves in the direction of flow during

molding. This would result in lower strength in a crosswise direction (i.e., across the flow) than in the longitudinal direction.

In ring and tensile test results, given in the tables, anistropic effects were particularly evident at low temperature (–65°F). In these tests, Alathon 2886 containers showed the most severe difference between crosswise and longitudinal strength (43% less strength in the crosswise direction). Other containers ranged from approximately 27% lower crosswise strength to essentially equal strength in both directions.



LIST OF MATERIALS

Material	Supplier
Alathon 2904	E. I. DuPont de Nemours and Co., Inc.
Alathon 2886	E. I. DuPont de Nemours and Co., Inc.
Alathon 7511	E. I. DuPont de Nemours and Co., Inc.
Bakelite DMDA 6087	Union Carbide and Carbon Corp.
Bakelite DMDA 7125	Union Carbide and Carbon Corp.
Dow 401	Dow Chemical Company
Dow 600	Dow Chemical Company
Grace 60–015	W. R. Grace Plastics Company
Phillips 6015	Phillips Chemical Company

TABLE 1

Alathon 2886 Resin (Design 2, Batch 1)

Density reported by manufacturer:	0.955
Density of molded part:	0.962
Melt index reported by manufacturer:	3.0
Melt index of resin:	2.06
Melt index of molded part:	1.5

DROP TEST*

Test Temperature, °F	Results
-65	Cracked in aft end; threads slipped
-55	Threads slipped
-20	Passed
73	Passed
120	Threads slipped
160	Threads slipped

EFFECTS OF THERMAL STRESS

Withstood 48 hours of storage at 160°F

MOLDING CONDITIONS

Injection Press Advanced	
1st Stage	18,000 psi
2nd Stage	1,500 psi
Cycle Temperature, °F	
Front	400
Middle	450
Rear	450
Mold Temperature, °F	
Both core and cavity	150
Cycle, seconds	
Injection	45
Booster	20
Cooler	70
Overall	210
Shot weight, oz	33

RING TEST RESULTS, FOR AFT END**

		Tensile Strength, psi	Jaw Travel, in., at 2 in./min.
At -65°F	Average	3603	.31
	High	4607	.31
	Low	2543	.31
At 73°F	Average	3111	.20
	High	3802	.25
	Low	2567 (Ring broke next to rib)	.19
At 160°F	Average	1783	.53
	High	2007	.69
	Low	1478	.38

TENSILE TEST RESULTS, FOR AFT END

		Tensile Strength, psi	Percent Elongation	Tensile Modulus
At -65°F	Average	6335	6.40	550,500
	High	6418	6.55	659,000
	Low	6282	6.20	457,000
At 73°F	Average	3893	11.0	238,500
	High	3989	11.5	349,000
	Low	3743	10.4	188,000
At 160°F	Average	1733	14.3	68,000
	High	1755	14.7	76,500
	Low	1640	14.0	57,500

*All containers tested at other than room temperatures were conditioned for 24 hours before testing.

**All rings tested at -65°F and 160°F broke.

TABLE 2

Alathon 2886 Resin (Design 2, Batch 2)

Density reported by manufacturer: 0.955

Melt index reported by manufacturer: 3.0

EFFECTS OF THERMAL STRESS

100 hours at 160°F dry – cracked; boiling water – 4 hours cracked

MOLDING CONDITIONS

Injection Press Advanced	
1st Stage	19,000 psi
2nd Stage	18,000 psi
Cycle Temperature, °F	
Front	400
Middle	450
Rear	450
Mold Temperature, °F	
Core	95
Cavity	155
Cycle, seconds	
Injection	75
Booster	20
Cooling	120
Overall	180–190
Shot weight, oz	40

RING TEST RESULTS FOR AFT END OF CONTAINER AT 73°F

	Tensile Strength, psi
At Open End of Section	
Average	3863
High	3939
Low	3757
At Closed End of Section	
Average	3967
High	4056
Low	3904

TENSILE TEST RESULTS FOR AFT END AT 73°F

	Tensile Strength, psi	Percent Elongation	Tensile Modulus
Average	3791	10.2	229,000
High	3909	10.8	289,000
Low	3610	9.6	190,000

TABLE 3

Alathon 2904 Resin (Design 3)

Density reported by manufacturer:	0.955
Density of molded part:	0.96
Melt index reported by manufacturer:	3.0
Melt index of molded part:	2.8–2.9

DROP TEST

Test Temperature, °F	Results
-65	Cracked
-40	One container passed all drop-tests; one cracked
73	Passed
160	Passed

EFFECTS OF THERMAL STRESS

24 hours at 160°F – dry – passed

MOLDING CONDITIONS

Injection Press Advanced	
1st stage	19,000 psi
2nd stage	16,000 psi
Cycle Temperature, °F	
Front	400
Middle	450
Rear	450
Mold Temperature, °F	
Zone 1, Cavity	100
Zone 2, Cavity	100
Zone 3, Sprue area	70
Zone 4, Core	70
Cycle, seconds	
Injection	45
Booster	20
Cooling	38
Overall	222
Shot weight, oz	41

RING TEST RESULTS

		Aft End		Center Section	
		Tensile Strength, psi	Jaw Travel, in., at 0.2 in./min.	Tensile Strength, psi	Jaw Travel, in., at 2 in./min.
At -65°F	Average	7123	.25	5372	.24
	High	7407	.29	5932	.23
	Low	6552	.20	4739	.21
			At 2 in./min.		At 0.2 in./min.
At -65°F	Average	7248	.24	5916	.29
	High	8129	.29	6260	.37
	Low	6765	.23	5396	.23
			At 2 in./min.		At 2 in./min.
At 73°F	Average	3988	.58	3926	.78
	High	4108	.69	4015	.86
	Low	3800	.54	3785	.70
At 160°F	Average	1764	.80		
	High	1814	.81		
	Low	1734	.75		

TENSILE TEST RESULTS

		Aft End			Center Section		
		Tensile Strength, psi	Percent Elongation	Tensile Modulus	Tensile Strength, psi	Percent Elongation at 0.2 in. min.	Tensile Modulus
At -65°F	Average	7479	5.85	502,000	7159	5.47	518,000
	High	7771	7.25	551,500	7295	6.00	579,000
	Low	7308*	3.8	429,000	7040	4.70	440,000
						At 2 in. min.	
At -65°F	Average				7675	6.75	521,500
	High				7883	6.50	576,500
	Low				7594	5.50	482,500
At 73°F	Average	3671	11.4	184,500	3894	12.17	218,000
	High	3731	13,0	204,000	3922	12.50	226,000
	Low	3643	9.2	153,500	3860	11.95	207,000
At 160°F	Average	1761	13.3	93,500			
	High	1842	14.9	80,500			
	Low	1706	12.5	69,600			

*Broke

TABLE 4

Alathon 7511 Resin (Design 2)

Density reported by manufacturer:	0.96
Density of molded part:	0.36–0.47
Melt index reported by manufacturer:	0.3
Melt index of molded part:	0.953–0.959
Molding conditions:	Unknown

DROP TEST

Test Temperature, °F	Result
–40	Cracked in aft end of container

EFFECTS OF THERMAL STRESS

72 hours at 160°F – dry; slight cracks at outside ribs

RING TEST RESULTS, FOR AFT END

		Tensile Strength, psi	Jaw Travel, in., at 0.2 in./min.
	Average	5167	.19
At –65°F*	High	5776	.19
	Low	4290	.19
			at 2 in./min.
	Average	3341	.19
At 73°F**	High	3529	.19
	Low	3216	.19
	Average	1933	.61
At 160°F***	High	2006	.69
	Low	1853	.56

TENSILE TEST RESULTS, FOR AFT END

		Tensile Strength, psi	Percent Elongation	Tensile Modulus
	Average	7053	6.35	609,500
At –65°F	High	7128	6.75	730,000
	Low	6978	6.08	533,500
	Average	4473	9.57	225,000
At 73°F	High	4681	10.15	221,500
	Low	4376	9.05	229,000
	Average	2005	19.2	71,000
At 160°F	High	2100	22.1	76,000
	Low	1905	15.2	66,000

*All broke in rib.
**Three broke next to rib, one in rib.
***Three broke, one in rib.

TABLE 5

Bakelite DMDA 6087 Resin (Design 2)

Density reported by manufacturer:	0.962
Density of molded part:	0.96
Melt index reported by manufacturer:	2.0
Melt index of molded part:	1.9–2.1

DROP TEST

Test Temperature, °F	Result
–40	Cracked

EFFECTS OF THERMAL STRESS

48 hours at 160°F–dry; passed

MOLDING CONDITIONS

Cycle Temperature, °F	
Front	400
Middle	450
Rear	450
Mold Temperature, °F	
Core	100–105
Cavity	95–100
Cycle, seconds	
Injection	45
Booster	–
Cooling	90
Overall	–

RING TEST RESULTS, FOR AFT END

		Tensile Strength, psi	Jaw Travel, in., at 2 in./min.
At –65°F	Average	5803	.22
	High	6290	.31
	Low	5549	.19
At –73°F	Average	4191	.58
	High	4372	.63
	Low	3965	.56
At 160°F	Average	1834	.73
	High	1976	.75
	Low	1781	.69

TENSILE TEST RESULTS, FOR AFT END

		Tensile Strength, psi	Percent Elongation	Tensile Modulus
At –65°F	Average	6898	5.10	648,000
	High	6925	5.95	711,000
	Low	6587	3.45	570,500
At 73°F	Average	4132	9.42	241,000
	High	4177	10.0	289,000
	Low	4079	8.5	209,500
At 160°F	Average	1767	13.4	83,000
	High	1805	14.1	89,500
	Low	1718	12.3	75,000

TABLE 6

Bakelite DMDA 7125 Resin (Design 2)

Density reported by manufacturer:	0.95
Density of molded part:	0.95–0.957
Melt index reported by manufacturer:	7.5
Melt index of molded part:	6.4

DROP TEST

Test Temperature, °F	Result
–40	Cracked

EFFECTS OF THERMAL STRESS

48 hours at 160°F–dry; passed

MOLDING CONDITIONS

Cycle Temperature, °F	
Front	400
Middle	450
Rear	450
Mold Temperature, °F	
Core	100–105
Cavity	95–100
Cycle, seconds	
Injection	45
Booster	–
Cooling	90
Overall	–

RING TEST RESULTS, FOR AFT END

		Tensile Strength, psi	Jaw Travel, in., at 2 in./min.
At –65°F	Average	4945	.41
	High	5281	.44
	Low	4357	.38
At 73°F	Average	2278	.19
	High	2768	.25
	Low	1877	.13
At 73°F	Average	3089*	
	High	3186	
	Low	2660	
At 160°F	Average	1206	0.97
	High	1240	1.0
	Low	1150	0.94

TENSILE TEST RESULTS, FOR AFT END

		Tensile Strength, psi	Percent Elongation	Tensile Modulus
At –65°F	Average	5743	4.71	507,000
	High	5939	5.63	566,000
	Low	5496	3.20	439,500
At 73°F	Average	3072	11.0	161,000
	High	3103	11.4	181,500
	Low	2989	10.4	126,500
At 160°F	Average	1270	14.3	45,500
	High	1294	14.9	52,500
	Low	1244	13.9	34,500

*This second set of tensile strength values was taken from two more containers from the same batch. The differences in results indicate an inconsistency in molding procedure.

TABLE 7

Dow 401 Resin (Design 2)

Density reported by manufacturer:	0.95
Density of molded part:	0.95
Melt index reported by manufacturer:	1.0
Melt index of molded part:	1.1

DROP TEST

Test Temperature, °F	Results
-40	Cracked
73	Threads slipped

EFFECTS OF THERMAL STRESS

72 hours at 160°F – dry; cracked at ribs

MOLDING CONDITIONS

Injection Press Advanced	
1st Stage	1400 psi
2nd Stage	1200 psi
Cycle Temperature, °F	
Front	450
Middle	450
Rear	400
Mold Temperature, °F	
Core	125
Cavity	90
Cycle, seconds	
Injection	75
Booster	61
Cooling	180
Overall	270

RING TEST RESULTS, AT AFT END

		Tensile Strength, psi	Jaw Travel, in., at 2 in./min.
At -65°F	Average	5846	.59
	High	6293	.63
	Low	5539	.56
At 73°F	Average	4172	.500
	High	4231	.500
	Low	4123	.500
At 160°F	Average	1800	.72
	High	1863	.75
	Low	1743	.69

TENSILE TEST RESULTS, FOR AFT END

		Tensile Strength, psi	Percent Elongation	Tensile Modulus
At -65°F	Average	6140	6.26	483,500
	High	6189	7.10	520,000
	Low	6100	5.28	397,500
At 73°F	Average	3622	9.92	158,000
	High	3672	10.15	193,000
	Low	3580	9.60	139,500
At 160°F	Average	1678	16.1	65,500
	High	1705	17.0	70,500
	Low	1642	15.8	60,000

TABLE 8

Dow 600 Resin (Design 2)

Density reported by manufacturer:	0.96
Density of molded part:	0.959
Melt index reported by manufacturer:	3.5
Melt index of molded part:	3.6

DROP TEST

Test Temperature, °F	Results
-40	Cracked
73	Threads slipped

EFFECTS OF THERMAL STRESS

72 hours at 160°F – dry; cracked

MOLDING CONDITIONS

Injection Press Advanced	
1st Stage	1400 psi
2nd Stage	1200 psi
Cycle Temperature, °F	
Front	450
Middle	450
Rear	400
Mold Temperature, °F	
Core	125
Cavity	90
Cycle, seconds	
Injection	75
Booster	61
Cooling	180
Overall	270

RING TEST RESULTS, FOR AFT END

		Tensile Strength, psi	Jaw Travel, in., at 2 in./min.
At -65°F	Average	6185	.25
	High	6484	.25
	Low	5876	.25
At 73°F	Average	3605	.281
	High	3898	.313
	Low	3341	.250
At 160°F	Average	1801	.73
	High	1822	.75
	Low	1782	.69

TENSILE TEST RESULTS, FOR AFT END

		Tensile Strength, psi	Percent Elongation	Tensile Modulus
At -65°F	Average	6732	5.77	586,500
	High	6884	5.93	620,000
	Low	6613	5.68	526,500
At 73°F	Average	4062	9.44	211,000
	High	4079	9.76	201,000
	Low	4035	9.30	159,500
At 160°F	Average	1818	12.7	80,500
	High	1902	13.6	96,000
	Low	1773	11.4	69,500

TABLE 9

Grace 60–015 Resin (Design 2)

Density reported by manufacturer:	0.96
Density of molded part:	0.963
Melt index reported by manufacturer:	1.5
Melt index of molded part:	1.4–1.5

DROP TEST

Test Temperature, °F	Result
–40	Passed

EFFECTS OF THERMAL STRESS

72 hours at 160°F – dry; passed

MOLDING CONDITIONS

Cycle Temperature, °F	
Front	450
Middle	450
Rear	475
Mold Temperature, °F	
Core	85–90
Cavity	120
Cycle, seconds	
Injection	9
Booster	20
Cooling	45
Overall	150

RING TEST RESULTS, FOR AFT END

		Tensile Strength, psi	Jaw Travel, in., at 2 in./min.
	Average	4993*	.34
At –65°F	High	5831	.38
	Low	4020	.31
	Average	4541**	
At 73°F	High	4708	
	Low	4380	
	Average***	3803	
At 73°F	High	3849	
	Low	3747	
	Average	2173	.61
At 160°F	High	2252	.68
	Low	2142	.56

TENSILE TEST RESULTS, FOR AFT END

		Tensile Strength, psi	Percent Elongation	Tensile Modulus
	Average	6637	6.50	520,500
At –65°F	High	6762	6.85	570,000
	Low	5676	6.14	470,500
	Average	4300	9.7	234,500
At 73°F	High	4364	10.0	250,500
	Low	4105	9.0	218,000
	Average	1792	14.9	77,000
At 160°F	High	1819	15.5	77,500
	Low	1748	13.8	76,500

*Specimen broke.

**All broke.

***Broke next to rib.

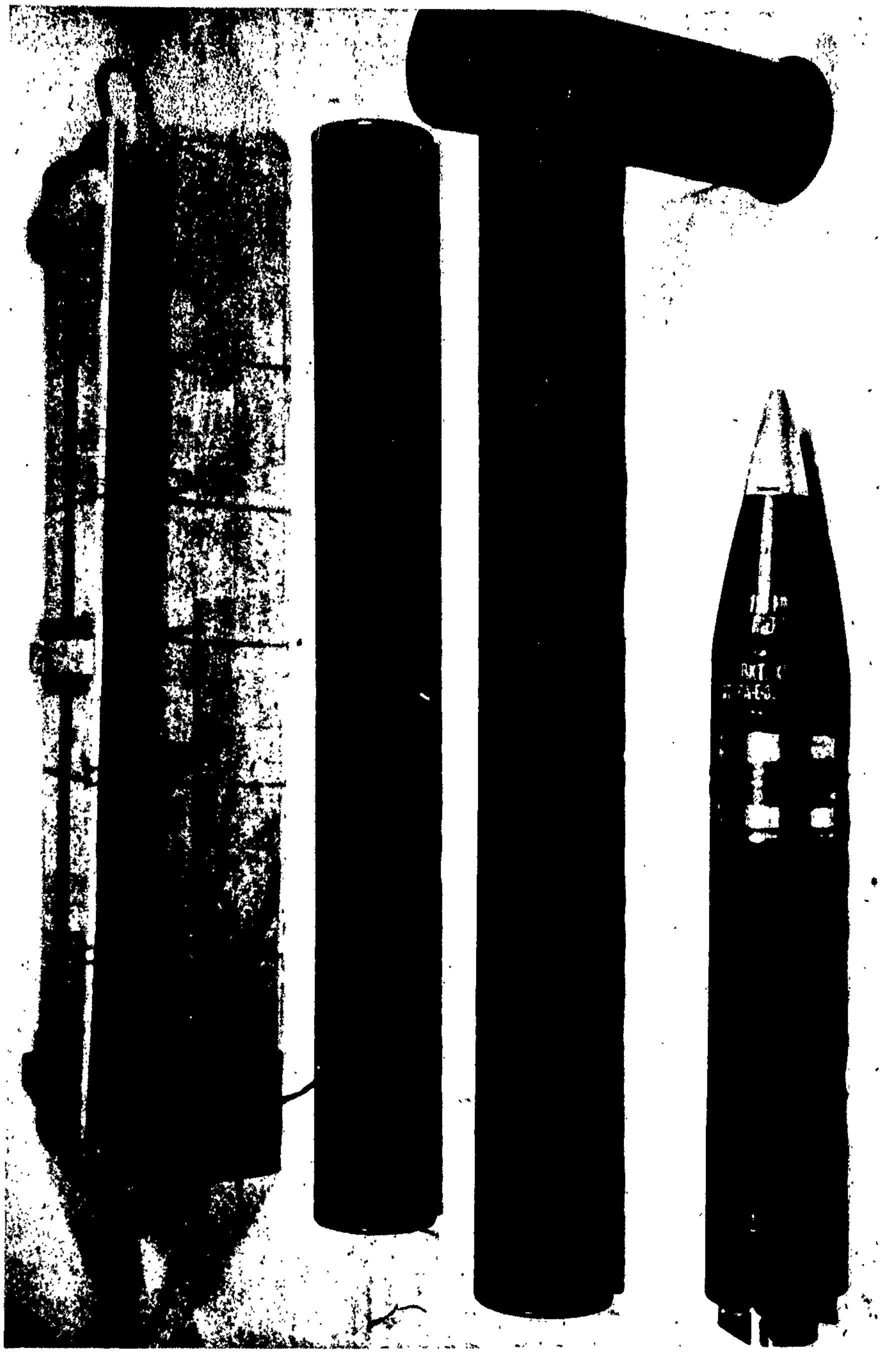


Fig 1 Fiber container overpacked in wooden box

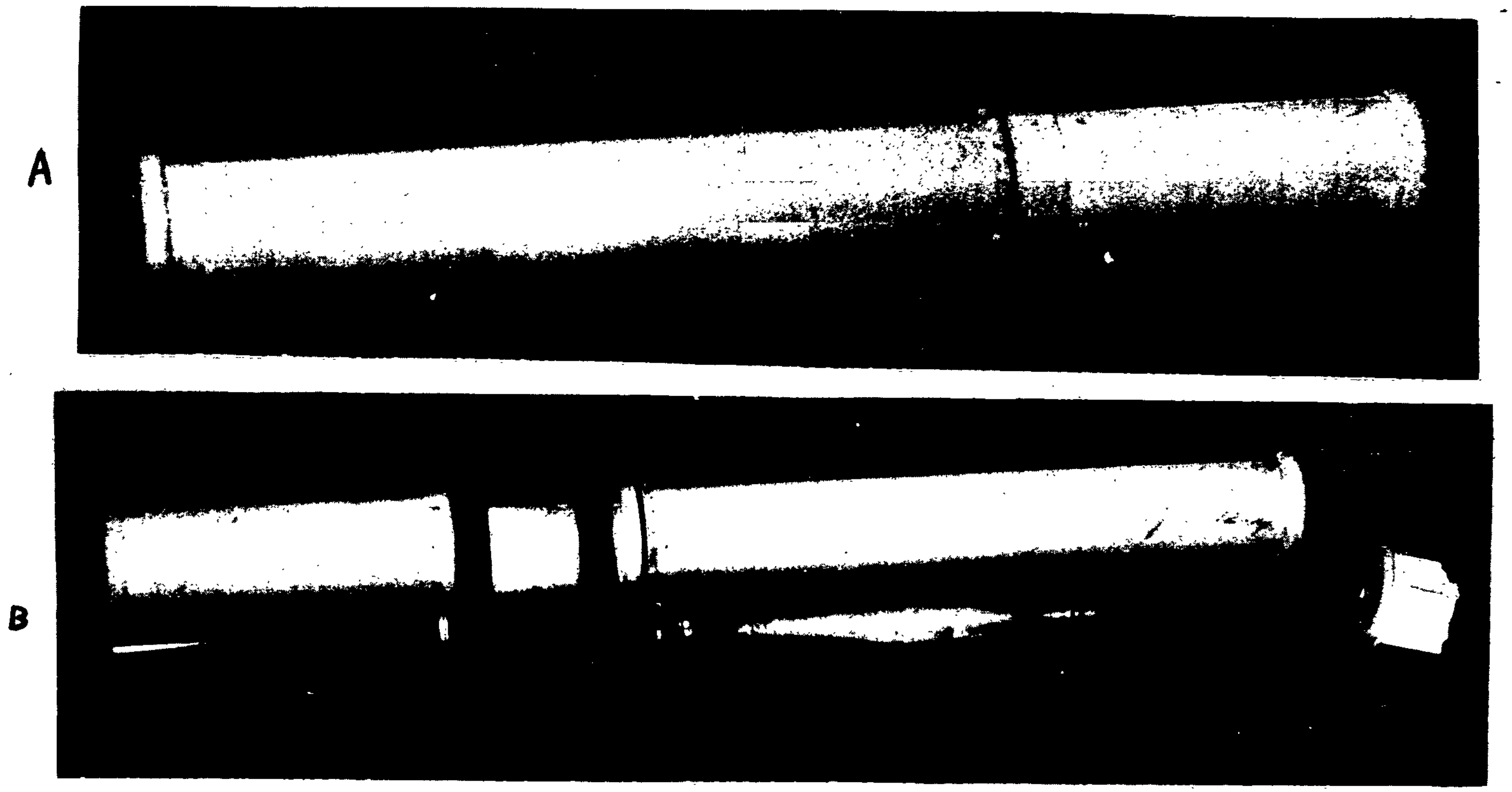


Fig 2 First container design with extruded tubes and injection molded end caps, base and nose supports, and threaded closures.

A – assembled
B – disassembled with contents

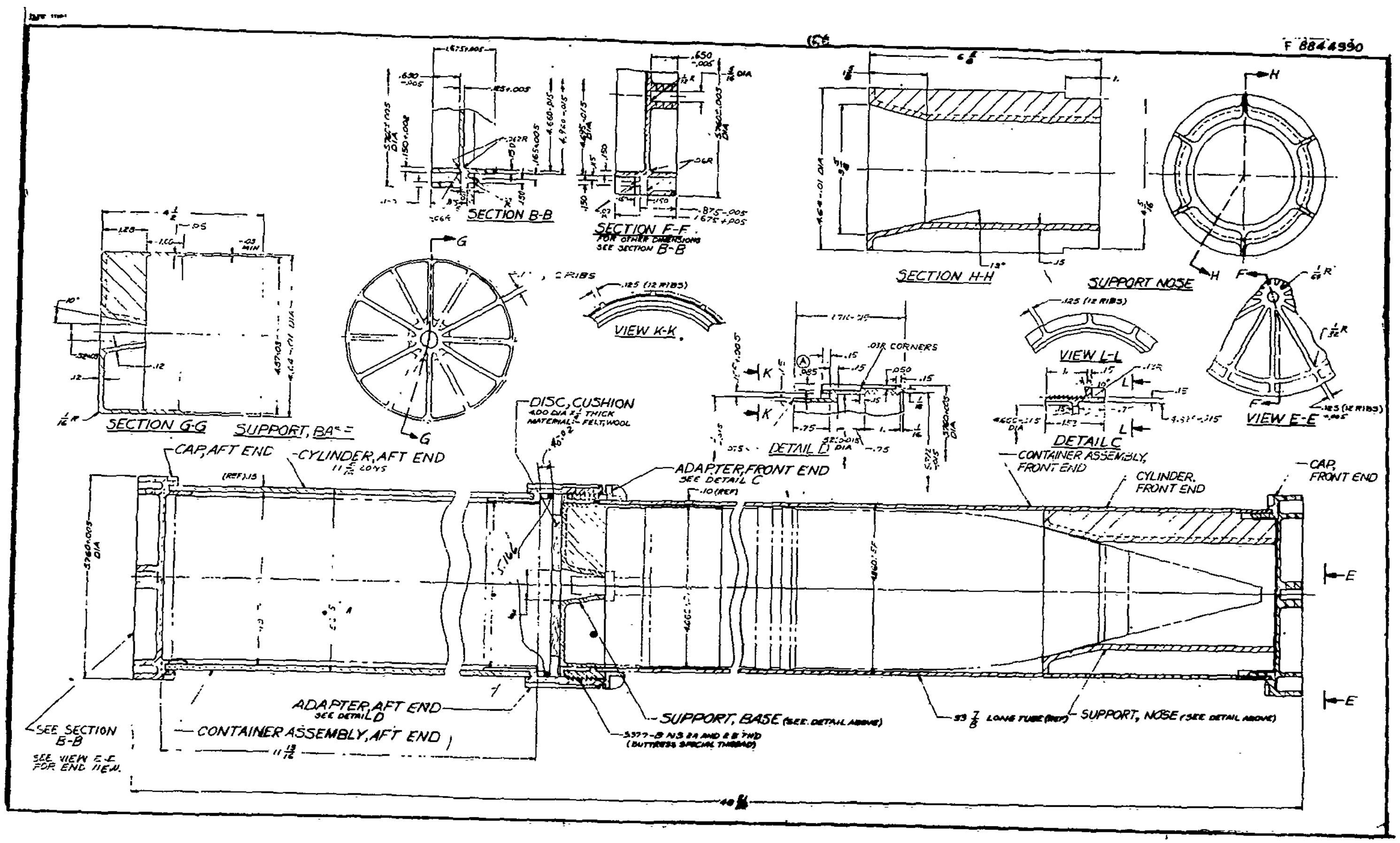


Fig 3 Design of prototype container

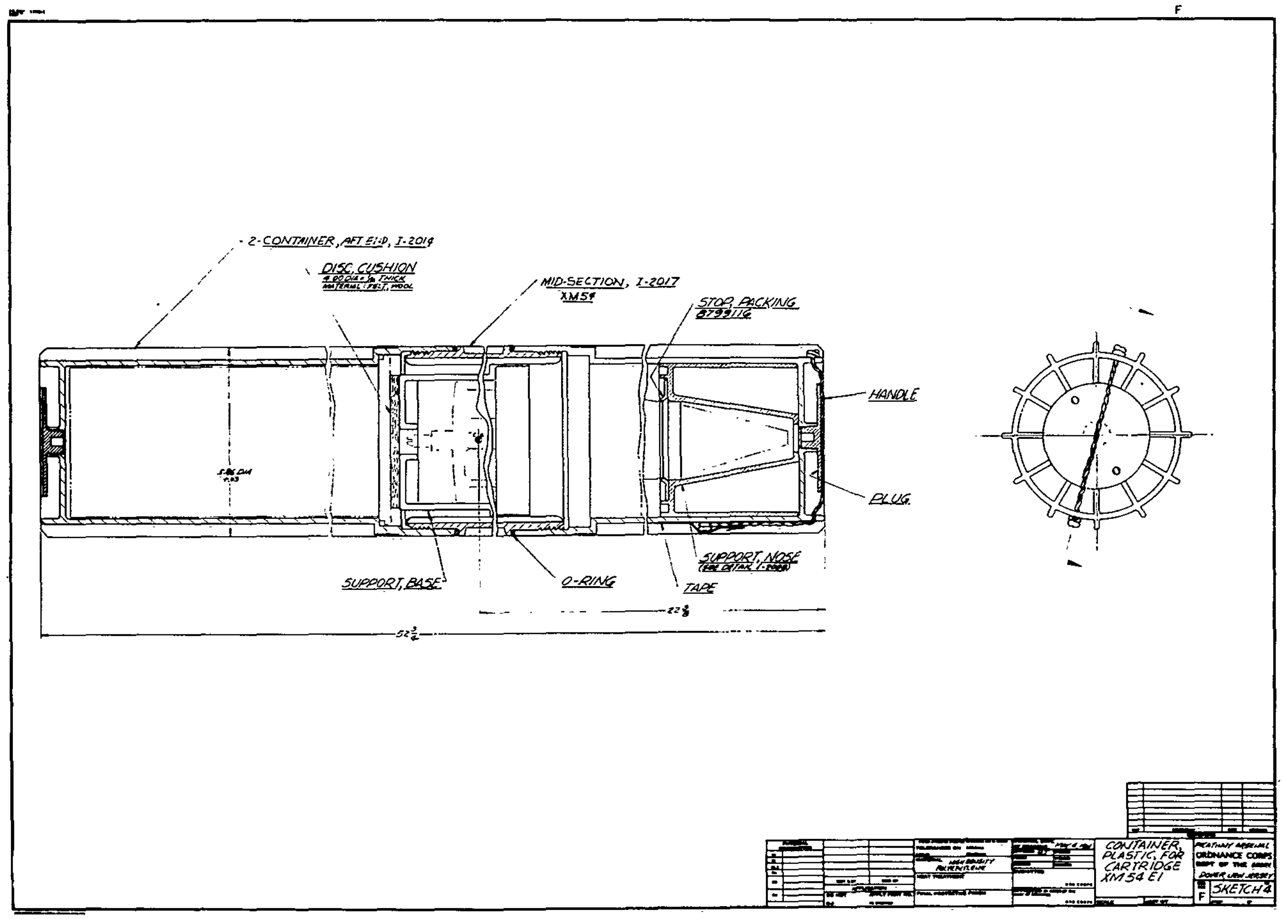


Fig 4 Design 1, a three-piece container with buttress thread, 8 threads per inch

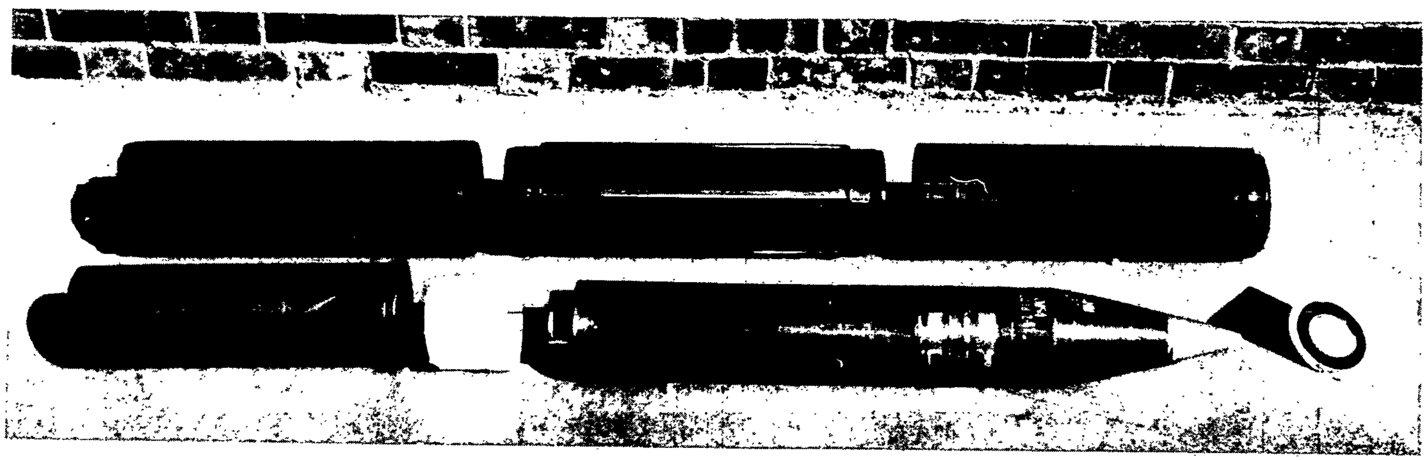


Fig 5 Three-piece container and contents

Fig 6 Three-piece container assembled

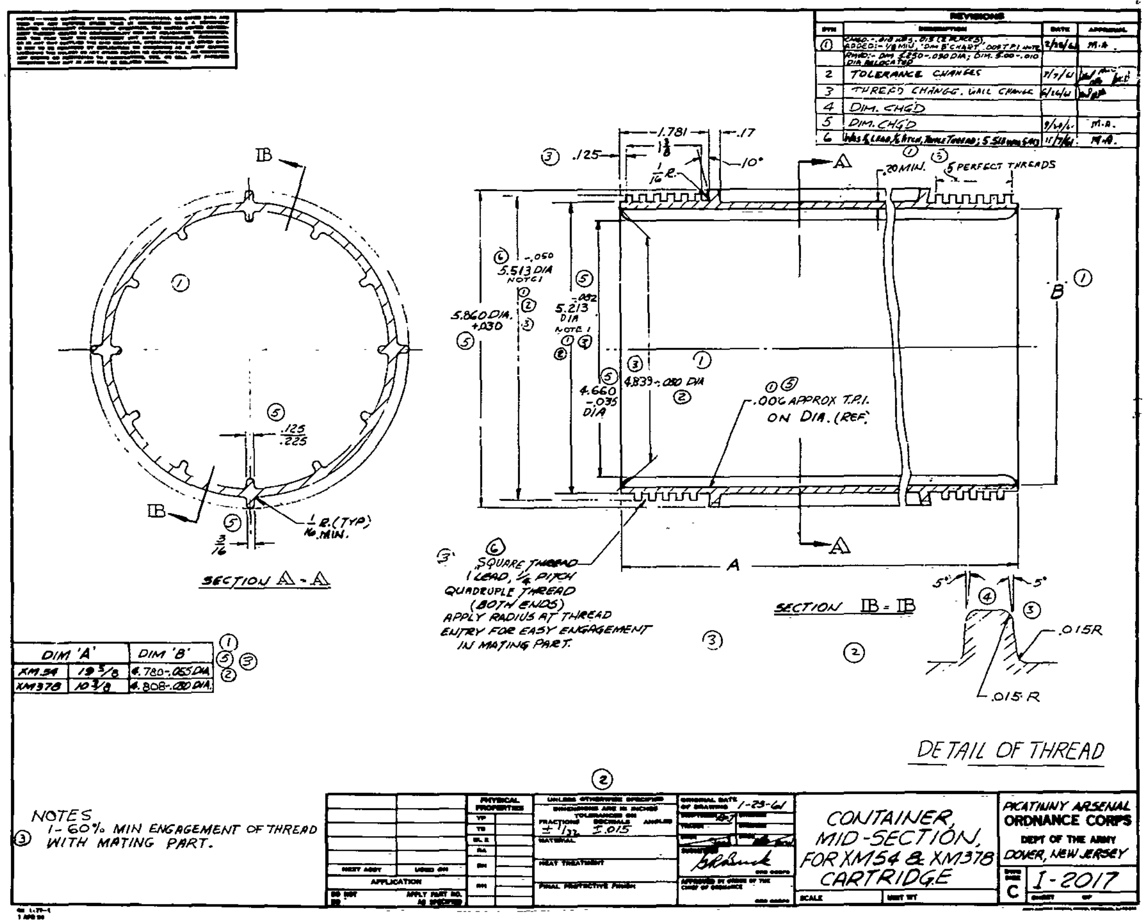


Fig 7 Design 2, midsection. Square threads, 0.1-inch deep, 6 threads per inch. Thickness increased from .17 inch to .20 inch.

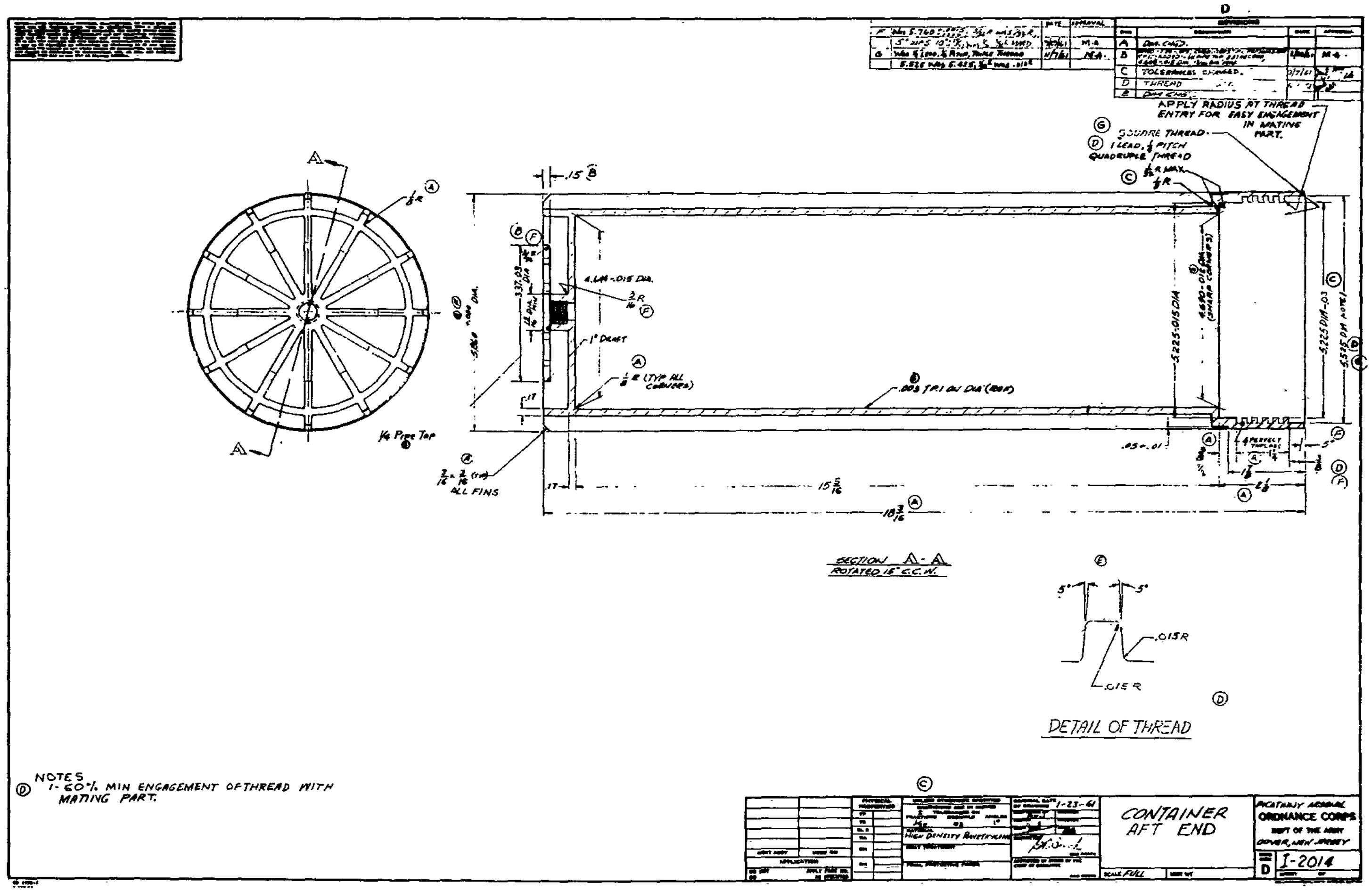


Fig 8 Design 3 (final), end sections. Increased wall thickness from 5.760 to 5.860, 4 threads per inch. Increased depth of thread from 0.1 inch to 0.15 inch.

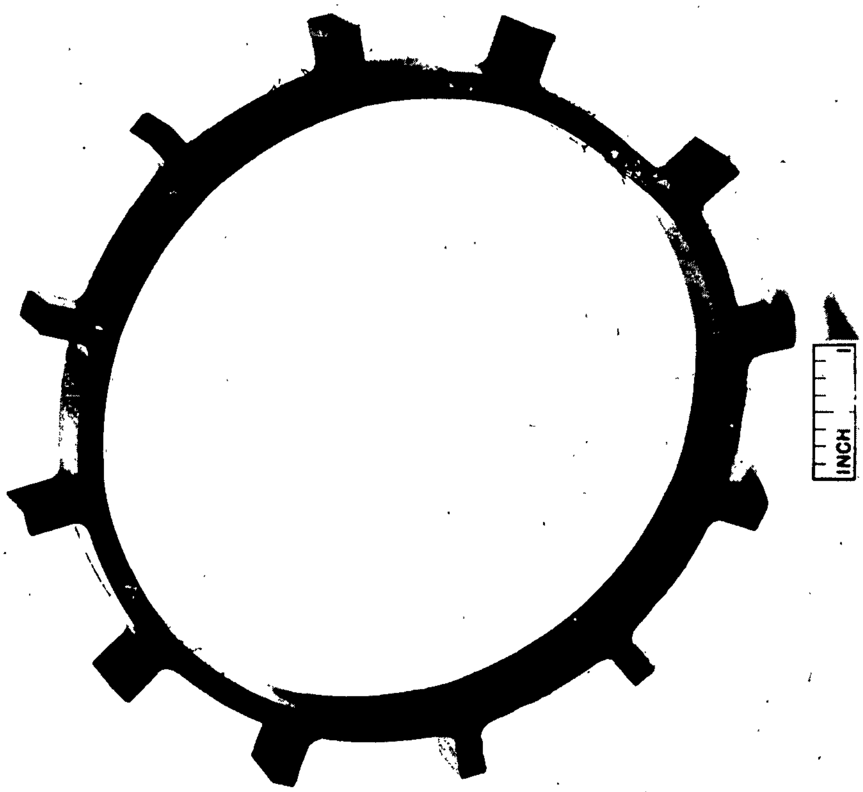


Fig 9   Ring cut from tested container, showing contamination

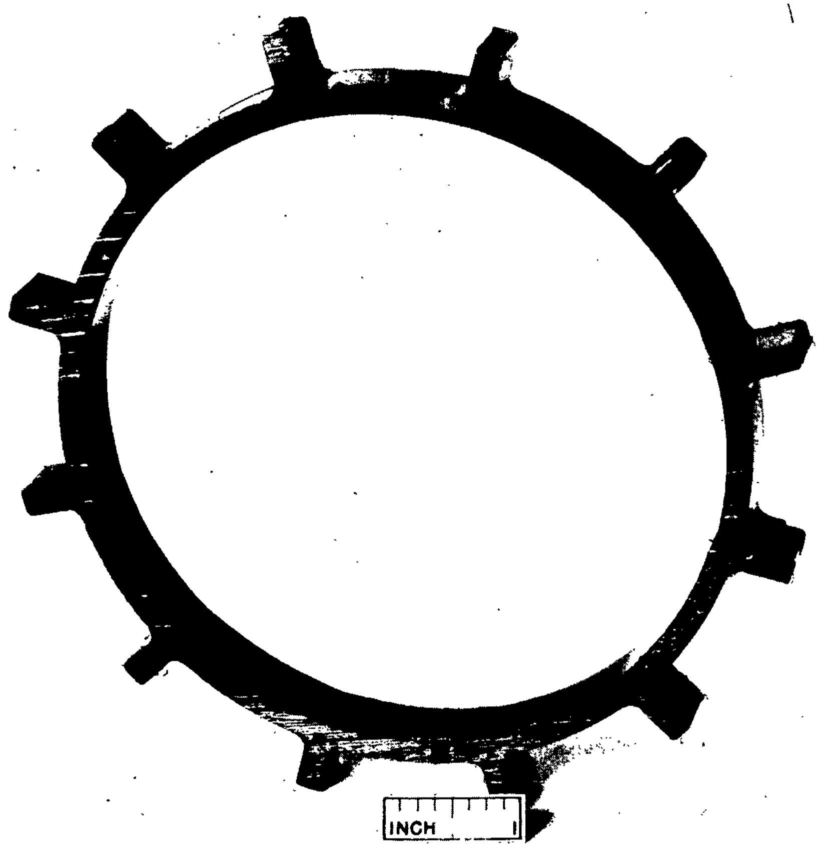


Fig 10 Ring cut from tested container, showing voids

Fig 11 Enlarged view, showing rupture due to contamination

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Michael Albanese and James M. Spilman

Technical Memorandum 1079, June 1963, 40 pp, drawings, photographs, tables. Unclassified report from the Plastics Application and Ammunition Packaging Sections of the Plastics and Packaging Laboratory.

A high-density polyethylene was chosen for fabrication of the XM54 rocket container because of its light weight, good water and impact resistance, and low cost. Several methods of fabrication were considered for this application, including blow molding, injection molding, and extrusion.

The concept of blow molding was eliminated because the close tolerances required in the inside diameter and the threaded section of the container could not be

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In view of this problem, it was decided to use a three-piece injection-molded container. Several minor design changes were made on the three-piece container on the basis of test results, thereby giving the final design shown in Figure 8 (p 27).

Of the several resins tested, the two that appear most promising are Alathon 2904 and Grace 60–015. Phillips 6015 may also be satisfactory if a proper mold design can be established for use with this resin. Further testing of resins and designs is required, and optimum molding conditions must be established before a completely satisfactory container can be produced.

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